FORM PTO-1390 (REV 5-93) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 842FR/50684

U S APPLICATION NO (if known, see 37 CFR 1.5): 10/049834

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/04815	**26 May 2000**	**17 August 1999**

TITLE OF INVENTION
INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

APPLICANT(S) FOR DO/EO/US
Wolfgang SCHEIBE and Horst RESSEL

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1.	X	This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2.		This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3.	X	This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay Examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4.	X	A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5.	X	A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
		a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
		b. [X] has been transmitted by the International Bureau (PCT/IB/308)
		c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6.	X	A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7.	X	Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
		a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
		b. [ ] have been transmitted by the International Bureau.
		c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
		d. [X] have not been made and will not be made.
8.		A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9.	X	An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
10.	X	A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Item 11. to 16. below concern other document(s) or information included:

11.	X	An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12.	X	An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13.	X	A **FIRST** preliminary amendment.
		A **SECOND** or **SUBSEQUENT** preliminary amendment.
14.	X	A substitute specification and marked-up copy thereof.
15.		A change of power of attorney and/or address letter.
16.		Other items or information:

a. 4 sheets of drawings
b. Application Data Sheet
c.

U.S. APPLICATION NO (if known, see 37 CFR 1 5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/049834	PCT/EP00/04815	842FR/50684

17. [X] The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO $ 890.00	$890.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) $ 690.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2) $ 740.00		
Neither international preliminary examination fee (37 CFR 1.482) nor International search fee (37CFR 1.445(a)(2) paid to USPTO $ 1000.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $ 100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	37 - 20 =	17	X $18.00	$306.00	
Independent Claims	2 - 3 =	0	X $84.00	$	
Multiple dependent claims(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS=				$1,196.00	
Applicant claims Small Entity Status (See 37 CFR §1.27) ☐ yes ☒ no. Reduction by 1/2 for filing by small entity, if applicable.				$	
SUBTOTAL =				$1,196.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$1,196.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28,3.31). $40.00 per property +				$	
TOTAL FEE ENCLOSED =				$1,196.00	
				Amount to be: refunded	$
				Charged	$

a. ☒ Two checks, in the amount of **$1,196.00** for the filing fee, and **$40.00** for the assignment recording fee, are enclosed

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any overpayment to Deposit Account No. 05-1323 (Attorney Docket No. 842FR/50684). **A duplicate copy of this sheet is enclosed.**

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
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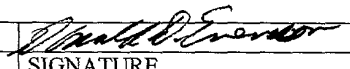

SIGNATURE
Donald D. Evenson
NAME
26,160
REGISTRATION NUMBER
February 19, 2002
DATE

DDE:SZ:tlm

APPLICATION DATA SHEET

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CORRESPONDENCE INFORMATION

Correspondence customer number:: 23911

APPLICATION INFORMATION

Title line one::	INJECTION VALVE FOR AN
Title line two::	INTERNAL COMBUSTION ENGINE
Total drawing sheets::	4
Formal drawings::	Yes
Application type::	Utility
Docket Number::	842FR/50684

REPRESENTATIVE INFORMATION

Representative customer number:: 23911

CONTINUITY INFORMATION

This application is a::	U.S. National Phase of
Application one::	PCT/EP00/04815
Filing date::	May 26, 2000
Patent number::	

PRIOR FOREIGN APPLICATIONS

Foreign application one::	199 38 921.7
Filing date::	August 17, 1999
Country::	Germany
Priority claimed::	Yes

Attorney Docket: 842FR/50684
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: WOLFGANG SCHEIBE ET AL

Serial No.: TO BE ASSIGNED PCT NO.: PCT/EP00/04815

Filed: February 19, 2002

Title: INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

PRELIMINARY AMENDMENT

Box PCT **February 19, 2002**
Commissioner for Patents
Washington, D.C. 20231

Sir:

Please enter the following amendments to the specification, claims and abstract prior to the examination of the application.

IN THE SPECIFICATION:

A substitute specification and a marked-up copy thereof is attached herewith.

IN THE CLAIMS:

Please amend the claims as follows **(a marked-up version of the amended claims is attached hereto)**:

1. (Amended) An injection valve for an internal combustion engine comprising: a control valve, which is activated especially electromagnetically and, by means of a valve actuator, alternatively closes off or opens up an opening for the passages of a fluid, which is assigned to a sealing surface and, by these means, controls the pressure in a control pressure space, which is connected with

the passage opening, the valve actuator, in addition to an actuator sealing surface, which acts together with the sealing surface of the opening for the passage of fluid, having an actuator stop surface, which is disposed at a distance from the actuator sealing surface, the valve actuator having a valve rod which, in relation to the distance between the sealing surface and the stop surface of the actuator has an overlength, wherein, during the closing movement, the overlength is taken up by the elastic deformation of the valve rod.

2. (Amended) The injection valve of claim 1, wherein the stop surface of the actuator is significantly larger than the sealing surface.

3. (Amended) The injection valve of claim 1, wherein the valve actuator is formed with a one-part or a two-part valve rod.

4. (Amended) The injection valve of claim 3, wherein the valve actuator contains a valve body, which touches the front face of the valve rod and contains the sealing surface of the actuator.

5. (Amended) The injection valve of claim 4, wherein the valve body is constructed as a sphere, which interacts with the opening for the passage of fluid, forming a seal.

6. (Amended) The injection valve of claim 3, wherein the sealing surface of the actuator is the front face of the valve rod formed by the valve actuator.

7. (Amended) The injection valve of claim 3, wherein the valve actuator is essentially mushroom-shaped, the stem of the mushroom forming the valve rod and the stop surface of the actuator being an annular collar, concentrically surrounding the valve rod in the region of the mushroom cap.

8. (Amended) The injection valve of claim 3, wherein the valve actuator is divided in a dividing joint into an actuator stop, having the stop surface of the actuator, and a valve rod, which is in operative connection with the sealing surface and the stop of the actuator.

9. (Amended) The injection valve of claim 3, wherein the actuator stop is essentially mushroom-shaped, the stop surface of the actuator being an end face, contacting the valve rod in the region of the foot of the mushroom.

10. (Amended) The injection valve of claim 3, wherein the valve rod is guided axially movably in at least one guide bushing.

11. (Amended) The injection valve of claim 10, wherein a guide bushing is disposed at a small distance from the sealing surface of the actuator.

12. (Amended) The injection valve of claim 3, wherein the length of the valve rod is a multiple of its diameter.

13. (Amended) The injection valve of claim 1, wherein the sealing surface is formed in the end face of a disk-shaped insert part and adjoins the control pressure space on the side averted from the sealing surface.

14. (Amended) The injection valve of claim 13, wherein the insert part is formed in two parts with a first part, which contains an opening for the passage of fluid and a discharge choke and a second part at the control pressure space side, with a borehole, which connects the control pressure space with an opening for the passage of fluid.

15. (Amended) The injection valve of claim 14, wherein the second part contains an inlet choke, which is connected with the borehole.

16. (Amended) The injection valve of claim 13, wherein the insert part contains an inlet choke in addition to the outlet choke.

17. (Amended) The injection valve of claim 13, wherein the control pressure space is connected with an inlet choke.

18. (Amended) The injection valve of claim 13, wherein the rear end of the valve needle, averted from the nozzle needle seat surface, lies in the control pressure space.

19. (Amended) The injection valve of claim 18, wherein the insert part forms a stop for the valve needle.

20. (Amended) The injection valve of claim 13, wherein the insert part, a centering and holding clamp and a sleeve, in which at least one valve rod and at least one guide bushing with the actuator stop surface is taken up, form a structural unit, which can be pre-adjusted by itself in relation to the protrusion of the valve rod.

Please add the following new claims:

21. (New) An injection valve for an internal combustion engine comprising:

an opening having a sealing surface;

a stop displaced a distance from the opening; and

an electromagnetical control valve including:

a valve actuator having an opening position and a closing position, the valve actuator including:

an actuator sealing surface that engages the sealing surface of the opening when the valve actuator is at the closing position,

an actuator stop surface that engages the stop when the valve actuator is at the closing position, and

a valve rod disposed between the actuator sealing surface and the actuator stop surface, wherein when the valve actuator is at the closing position, the valve rod is compressed to a length that is shorter than a length of the valve rod when the valve actuator is at the opening position.

22. (New) The injection valve of claim 21, wherein the stop surface of the actuator is significantly larger than the sealing surface.

23. (New) The injection valve of claim 21, wherein the valve actuator is formed with a one-part or a two-part valve rod.

24. (New) The injection valve of claim 23, wherein the valve actuator contains a valve body, which is positioned at a front face of the valve rod and contains the sealing surface of the actuator.

25. (New) The injection valve of claim 24, wherein the valve body has the configuration of a sphere.

26. (New) The injection valve of claim 23, wherein the sealing surface of the valve actuator is a front face of the valve rod.

27. (New) The injection valve of claim 23, wherein the valve rod is axially movably guided in a guide bushing.

28. (New) The injection valve of claim 27, wherein a guide bushing is disposed near the actuator sealing surface.

29. (New) The injection valve of claim 23, wherein the length of the valve rod is a multiple of its diameter.

30. (New) The injection valve of claim 21 further comprising a disk-shaped insert having a first end face that includes the sealing surface, and a second end face adjoining a control pressure space.

31. (New) The injection valve of claim 30, wherein the insert has a first part, which includes the opening and a discharge choke, and a second part, which includes a borehole that connects the control pressure space with the opening.

32. (New) The injection valve of claim 31, wherein the second part of the insert includes an inlet choke, which is connected with the borehole.

33. (New) The injection valve of claim 30, wherein the insert includes an inlet choke.

34. (New) The injection valve of claim 30, wherein the control pressure space is connected to the inlet choke.

35. (New) The injection valve of claim 30 comprising a valve needle having an end disposed in the control pressure space.

36. (New) The injection valve of claim 35, wherein the insert part forms a stop for the valve needle.

37. (New) The injection valve of claim 30 further comprising a centering and holding clamp and a sleeve, wherein the insert part, the centering and holding clamp and the sleeve, in which the valve rod and the guide bushing that includes the actuator stop surface are placed, form a structural unit, which can be pre-adjusted in relation to the valve rod.

IN THE ABSTRACT:

Please add an Abstract of the Disclosure submitted herewith on a separate page.

REMARKS

Entry of the amendments to the specification, claims and abstract before examination of the application is respectfully requested.

If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

1. (Amended) An injection valve for an internal combustion engine [with] comprising: a control valve, which is activated especially electromagnetically and, by means of a valve actuator [(12)], alternatively closes off or opens up an opening [(14a)] for the passages of a fluid, which is assigned to a sealing surface [(13, 17)] and, by these means, controls the pressure in a control pressure space [(14)], which is connected with the passage opening, the valve actuator [(12)], in addition to an actuator sealing surface [(16a)], which acts together with the sealing surface [(17)] of the opening [(14a)] for the passage of fluid, having an actuator stop surface [(12a)], which is disposed at a distance from the actuator sealing surface [(16a)], the valve actuator [(12)] having a valve rod [(16)] which, in relation to the distance between the sealing surface [(16a)] and the stop surface [(12a)] of the actuator has an overlength, wherein, during the closing movement, the overlength is taken up by the elastic deformation of the valve rod [(16)].

2. (Amended) The injection valve of claim 1, wherein the stop surface [(12a)] of the actuator is significantly larger than the sealing surface [(16a)].

3. (Amended) The injection valve of [claims 1 or 2] claim 1, wherein the valve actuator [(12)] is formed with a one-part or a two-part valve rod [(16)].

4. (Amended) The injection valve of claim 3, wherein the valve actuator [(12)] contains a valve body [(30)], which touches the front face of the valve rod [(16)] and contains the sealing surface [(16a)] of the actuator.

5. (Amended) The injection valve of claim 4, wherein the valve body [(30)] is constructed as a sphere, which interacts with the opening [(14a)] for the passage of fluid, forming a seal.

6. (Amended) The injection valve of claim 3, wherein the sealing surface [(16a)] of the actuator is the front face of the valve rod [(16)] formed by the valve actuator [(12)].

7. (Amended) The injection valve of [one of the claims 3 to 6] claim 3, wherein the valve actuator [(12)] is essentially mushroom-shaped, the stem of the mushroom forming the valve rod [(16)] and the stop surface [(12a)] of the actuator being an annular collar, concentrically surrounding the valve rod [(16)] in the region of the mushroom cap.

8. (Amended) The injection valve of [one of the claims 3 to 7] claim 3, wherein the valve actuator [(12)] is divided in a dividing joint [120] into an actuator stop, having the stop surface [(12a)] of the actuator, and a valve rod [(16)], which is in operative connection with the sealing surface [(16a)] and the stop of the actuator.

9. (Amended) The injection valve of [one of the claims 3 to 8] claim 3, wherein the actuator stop is essentially mushroom-shaped, the stop surface [(12a)] of the actuator being an end face, contacting the valve rod [(16)] in the region of the foot of the mushroom.

10. (Amended) The injection valve of [one of the claims 3 to 9] claim 3, wherein the valve rod [(16)] is guided axially movably in at least one guide bushing [(15o, 15u)].

11. (Amended) The injection valve of claim 10, wherein a guide bushing [(15u)] is disposed at a small distance from the sealing surface [(16a)] of the actuator.

12. (Amended) The injection valve of [one of the claims 3 to 11] claim 3, wherein the length of the valve rod [(16)] is a multiple of its diameter.

13. (Amended) The injection valve of [claims 1 to 12] claim 1, wherein the sealing surface [(17)] is formed in the end face of a disk-shaped insert part [(32)] and adjoins the control pressure space [(14)] on the side averted from the sealing surface [(17)].

14. (Amended) The injection valve of claim 13, wherein the insert part [(32)] is formed in two parts with a first part [(37)], which contains an opening [(14a)] for the passage of fluid and a discharge choke [(33)] and a second part [(34)] at the control pressure space side, with a borehole [(35)], which connects the control pressure space [(14)] with an opening [(14a)] for the passage of fluid.

15. (Amended) The injection valve of claim 14, wherein the second part [(34)] contains an inlet choke [(36)], which is connected with the borehole [(35)].

16. (Amended) The injection valve of claim 13, wherein the insert part [(32)] contains an inlet choke [(36)] in addition to the outlet choke [(33)].

17. (Amended) The injection valve of [claims 13 or 14] claim 13, wherein the control pressure space [(14)] is connected with an inlet choke [(36)].

18. (Amended) The injection valve of [one of the claims 13 to 17] claim 13, wherein the rear end of the valve needle [(20)], averted from the nozzle needle seat surface, lies in the control pressure space [(14)].

19. (Amended) The injection valve of claim 18, wherein the insert part [(32)] forms a stop for the valve needle [(20)].

20. (Amended) The injection valve of [one of the claims 13 to 19] claim 13, wherein the insert part [(32)], a centering and holding clamp [(39)] and a sleeve [(38)], in which at least one valve rod [(16)] and at least one guide bushing [(15o, 15u)] with the actuator stop surface [(12a)] is taken up, form a structural unit, which can be pre-adjusted by itself in relation to the protrusion of the valve rod.

Attorney Docket: 842FR/50684
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: WOLFGANG SCHEIBE ET AL

Serial No.: TO BE ASSIGNED PCT NO.: PCT/EP00/04815

Filed: FEBRUARY 19, 2002

Title: INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

SUBMISSION OF SUBSTITUTE SPECIFICATION

Commissioner for Patents
Washington, D.C. 20231

February 19, 2002

Sir:

Attached is a Substitute Specification and a marked-up copy of the original specification. I certify that said substitute specification contains no new matter and includes the changes indicated in the marked-up copy of the original specification.

Respectfully submitted,

Donald D. Evenson
Registration No. 26,160
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Registration No. 44,420

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INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates to an injection valve for an internal combustion engine with a control valve, which is activated electromagnetically and, by means of a valve actuator, alternatively closes or opens an opening for the passages of a fluid and, by these means, controls the pressure in a control pressure space, which is connected with the passage opening.

A conventional injection valve is shown in Figure 2 of the European patent EP 0531 533 B1. The valve actuator of this injection valve is permanently connected with the armature of the electromagnet and is pressed by the force of a spring against the sealing surface to close the passage opening to the control pressure space. Such injection valves are usually used for storage injection systems, which utilizes very high control pressures in the order of several hundred bar. By supplying current to the electromagnet, the valve actuator, which is connected with the armature of the magnet, is raised against the force of a spring, to open the passage opening and to decrease the high pressure in the control pressure space. The injection in the injection valve is then initiated by the decrease in pressure in the control pressure space. By switching off the current to the magnetic coil, the magnet armature and the valve actuator, which usually is constructed as a cylindrical bolt, strike under the force of the spring with its front surface against the sealing surface and close the passage opening.

A good sealing effect of the valve actuator against the very high pressure in the control pressure space is achieved by a valve actuator, which has the smallest possible cross sectional surface and a smallest possible diameter. The smallest possible diameter for the valve actuator is advantageous because errors in angle resulting from manufacturing inaccuracies, do not lead to leakage gaps. Errors in angle are deviations in the alignment of the face surface of the valve actuator with the associated sealing seat surface. Finally, a high sealing seat pressure and, with that, a more accurate control, are a third reason for having a valve actuator with the smallest possible diameter.

It is, however, a disadvantage of a valve actuator having a small diameter and a the small face surface that the seating impact at the valve opening may be impermissibly high. A further disadvantage is that the closing motion of the magnet armature and of the valve actuator, which together form an appreciable inertial mass, are retarded with little damping to zero, so that recoil effects occur. The largest possible diameter and a correspondingly large face surface would be desirable for a dampened braking.

It is an object of the present invention to develop an injection valve of the aforementioned construction in such a manner that the above-indicated conflict is resolved, and a high accuracy of the control valve is achieved even at extremely high pressures. At the same time, impermissibly high valve wear due to the impact movement of the valve actuator element is avoided.

Pursuant to the invention, this objective is accomplished by a valve actuator that has an actuator stop surface disposed at a distance from the actuator-sealing surface which interacts with the sealing surface of the opening for passage of fluid.

Due to the inventive, spatial separation of the actuator-sealing surface from the actuator stop surface, contrary requirements with respect to the sealing function and the impact damping function can be met at the same time. Accordingly, in an advantageous development of the invention, the actuator stop surface is significantly larger than the actuator-sealing surface. The locally separate construction of actuator stop surface and actuator sealing surface furthermore has the advantage that high fluid pressures, such as those in the regions of the opening for the passage of fluid and the sealing surface of the actuator, can be shifted locally from the electromagnet to protect the electromagnet against high hydraulic pressure. Finally, a further advantage is that the electromagnet can be protected better against the effect of the physical and chemical properties of the control fluid.

In a preferred embodiment of the inventive injection valve, the sealing surface of the actuator is the face side of a valve rod, formed by the valve actuator. In a different preferred embodiment, the valve actuator comprises a spherical valve body, which lies against the face side of the valve rod and acts together with the conical sealing surfaces of the passage opening. Moreover, the length of the valve rod is determined essentially by the distance between the

sealing surface of the actuator, or of the valve body stop of the valve rod, and the stop surface of the actuator. It is advantageous if the valve actuator is essentially mushroom-shaped, and the stalk of the mushroom forms the valve rod and the stop surface of the actuator. The mushroom cap of the valve actuator is an annular collar, which surrounds the valve rod concentrically.

The length of the valve rod is longer by a minimum amount than the distance between the sealing surface of the opening for the passage of fluid or the valve body stop of the valve rod and the reference stop for the stop surface of the actuator.

A preferred embodiment of the invention includes a valve actuator divided at a separating joint into an actuator stop having an actuator stop surface and a valve rod, which is in operative connection with the sealing surface and the stop of the actuator.

It is a significant advantage of this invention that the valve rod with a smaller diameter can be more easily produced independently of the actuator stop. A further advantage is that different materials can be used for the valve rod and the actuator stop. For the divided construction of the valve actuator, it is only necessary to ensure that the opening motion of the valve rod, that is, the lifting from the sealing surface, is ensured by excess pressure from the opening for the passage of fluid or by a supporting, auxiliary spring. The slight excess length of the valve rod, in relation to the distance between the sealing surface of the actuator or the stop of the valve body and the stop surface of the actuator (valve

rod protrusion), can be accommodated during the closing motion by the elastic deformation (shortening) of the valve rod.

It is advantageous if the actuator stop is essentially mushroom-shaped, the actuator stop surface being a face surface coming into contact with the valve rod in the region of the foot of the mushroom. Usually, the face surface will be a circular surface, the diameter of which is clearly greater than the diameter of the impacting valve rod.

In a further development of the invention, the valve rod is guided axially movably in guide bushings. Moreover, in an effort to keep the sealing surface of the actuator small, a guide bushing is disposed at a small distance from the actuator-sealing surface of the valve rod. In this way, bending vibrations of the free end of the valve rod with the actuator sealing surface are prevented, so that the diameter of the actuator sealing surface need only be slightly larger than that of the passage borehole.

The length of the valve rod preferably is a multiple of its diameter.

In an advantageous development, the sealing surface of the actuator is assigned to a one-part or two-part disk-shaped insert, the control-pressure space adjoining on the side averted from the sealing surface. From a material point of view, the appropriate insert can be adapted with little effort to different stress cases and, by these means, the seal can be improved. With that, of course, by means of parts with different throttling boreholes, which can be combined in modular fashion, supplying and discharging throttles being assigned to different

parts, it also being possible to comply with the different requirements of injection characteristics in a simple manner.

BRIEF DESCRIPTON OF THE DRAWINGS

An example of the invention is explained by means of the attached drawings, in which

Figure 1 shows an inventive injection valve in longitudinal section,

Figure 2 shows an enlargement of the region of the electromagnetic control valve of the injection valve of Figure 1,

Figure 3 shows a section of an electromagnetic control valve of the state of the art on a scale, greatly enlarged even more in comparison to that of Figure 2,

Figure 4 shows a variation of the injection valve with an insert in the region of the sealing surface of the actuator,

Figure 5 shows an enlarged view of the immediate region of the actuator surface with a spherical valve body disposed at the end of the valve rod and

Figure 6 shows a variation of an inventive injection valve in longitudinal section, the valve needle lying with its end, which is averted from the injection openings, directly in the control pressure space.

DETAILED DESCRIPTON OF THE DRAWINGS

The injection valve of a high-pressure, storage injection system for an internal combustion engine, shown in Figure 1, has a housing 1. In the lower

region of the injection valve, a valve needle 20 is mounted. The axial movement of the valve needle 20 opens an injection hole 24 connected to a high pressure space 21 so that an injection takes place. The high-pressure space 21 is connected with a high-pressure connection 22 through ducts in the housing 1. The movement of the nozzle needle 20 is controlled by an electromagnet 10, the magnet armature 11 of which is permanently connected with a valve actuator 12. The valve actuator 12 is part of a control valve, which is actuated by the electromagnet 10. The function of this electromagnetically actuated control valve is explained with reference to Figure 2.

Identical components in Figure 2 have been given the same reference numbers as used in Figure 1. The actuator 12 is essentially mushroom-shaped. The stem of the mushroom is constructed as a valve rod 16, which extends from the region of the mushroom cap up to the sealing surface 17 having an opening 14a for the passage of fluid from the pressure control space 14. The diameter of the valve rod 16 is selected so that the face surface just covers the opening 14a for the passage of fluid and thus forms a sealing seat on the sealing surface 17. It can be seen easily that the length of the valve rod 16 is a multiple of its diameter. The pressure control space 14 is connected over a throttle borehole with the high-pressure duct system of the injection valve. At the housing, the actuator 12 is mounted axially displaceably by the valve rod 16 in an upper guide bushing 15o and a lower guide bushing 15u. Moreover, the lower guide bushing 15u is disposed so that there is only a small distance between the lower end of the valve rod 16, which is constructed as an actuator surface 16a, and the bottom

edge of the lower guide bushing 15u. The annular space 18, which is formed there, is connected with a low-pressure fluid connection 19 of the injection valve. In the closed position of the electromagnetic control valve, shown in Figure 2, the actuator sealing surface 16a of the valve rod 16 closes off the borehole 14a. An annular collar, surrounding the valve rod 16 concentrically in the region of the mushroom cap of the actuator 12, is constructed as an actuator stop surface 12a and rests on the upper plane surface of the bushing 15o. In the closed position of the electromagnetic control valve that is shown, the valve actuator 12, together with the magnet armature 11, is acted upon by a compression spring, the details of which are not shown and which presses the actuator 12 against the sealing surface 17 and onto the upper side of the upper guide bushing 15o, which acts as reference stop for the stop surface 12a of the actuator 12. If electric power is supplied to the electric magnet 10, the magnetic armature 11 pulls the actuator 12 up against the force of the compression spring. As a result, the borehole 14a for the passage of fluid is opened, and a pressure decrease results in the control pressure space 14, which brings about a lifting of the valve needle 20 and, with that, an injection. When the power is switched off, the force of the compression spring knocks the valve actuator 12, together with the armature of the magnet 11, downward. Moreover, the stop surface 12a of the actuator 12, which is much larger than sealing surface 16a of the actuator of the valve rod 16, acts strictly as a damping and stop surface for decaying the mass forces of the magnet armature and of the valve actuator. At the lower end of the valve rod 16, the very much smaller sealing surface 16a of the actuator 12 takes over the function of a sealing

seat and, because of the small surface itself, does so with great accuracy and without the risk of leakages even at extremely high control pressures.

The risk of leakage in a conventional injection valve is indicated by means of a greatly enlarged representation of Figure 3. The structure of this valve is similar to that shown in Figures 1 and 2, with the difference that the opening 14a for the passage of fluid, which is connected to the control pressure space 14, is at housing surface 13, which has the function of both a stop and a sealing surface. The valve actuator 12 once again has a mushroom shape, but does not have the inventive valve rod 16. In order for the damping and impact effect of the valve actuator 12 not to become too small, the diameter of the sealing seat and impact surface is selected to be clearly larger than the diameter of the opening 14a for the passage of fluid. Therefore, there is the risk that an angular error, that is, a deviation of the sealing and stop surface from precisely a right angle with respect to the longitudinal axis of the valve actuator 12 may produce, a small gap 5, even when the valve actuator 12 is in contact with the housing surface 13. Such a small gap can result in a permanent drop in pressure in the high pressure region 14.

A region of an injection valve, which corresponds to that of Figure 2 and is modified in the region of the actuator-sealing surface, is shown in Figure 4. As shown on an enlarged scale in Figure 6, the valve rod 16 acts on a valve body 30, which is constructed as a sphere. The valve body 30 lies in contact with a conically shaped sealing surface 17 of the opening 14a for the passage of fluid.

The opening 14a for the passage of fluid contains a discharge choke 33. The use of a separate valve body 30, which may also have a shape different from that of a sphere, has the advantage that the sealing is improved. In particular, it is also possible to use different materials for the valve rod 16 and the valve body 30. A further improvement of the sealing arises from the use of an insert part in the form of a disk-shaped part 37, which contains the drainage choke 33. With respect to the material and the borehole of the choke, this part 37 can easily be matched optimally to different stress cases. By making available insert parts with choke boreholes of different size, it is furthermore possible to vary the injection characteristics by a simple exchange. Likewise, it is possible to make available second parts 34 with different inlet chokes 36, in order to match the injection characteristics by a simple exchange. This procedure of changing the amount injected and the course of the injection by replacing first and second insert parts with different chokes is known, as such, from the EP 0 844 385 A1. By means of a centering and holding clamp 39, the part 37 is connected with a sleeve 38, in which the valve rod 16 with its guide bushings 15o and 15u is disposed. These parts form a structural unit, which can be adjusted by themselves in relation to the projecting length of the valve rod.

Figure 5 shows an inventive injection valve, which also contains a disk-shaped insert part 32. The control pressure space 14 adjoins immediately the side of the insert part 32, which is averted from the sealing surface 17. With its rear end, the nozzle needle 20 lies directly in the pressure control space 14. The insert part 32 is incorporated between the nozzle holder and the injection nozzle

40. The injection nozzle 40 and the insert part 32 are pressed against the nozzle holder by a nozzle nut, so that the high pressure regions are connected with one another. The insert part 32 has a central borehole as an opening 14a for the passage of fluid to the control pressure space 14 and a calibrated discharge choke 33 in the region opposite the valve rod 16. In addition, the insert part 32 contains a high-pressure duct 41, which passes the fuel under injection pressure from a high-pressure connection 22 to a high-pressure duct in the injection nozzle. The high-pressure duct 41 in the insert part 32 has a pipeline connection to the central borehole in the insert part 32 and there is a calibrated inlet choke 36 in this pipeline connection. Preferably, as shown in Figure 6, the insert part has a conical sealing surface 17, in which a spherical valve body 30 provides the seal. A corresponding construction is known from US patent 5,832,899.

In its function, the injector corresponds to that described in Figures 1 and 2. Because of the construction with the control spaces assigned directly to the two sides of the insert part, the sealing is reduced essentially to this region, which can easily be controlled. In particular, by making available a suitable insert part, it is easily possible to react to different stress cases and to different requirements with regard to the amount injected and to the course of the injection.

INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates to an injection valve for an internal combustion engine with a control valve, which is activated electromagnetically and, by means of a valve actuator, alternatively closes [off] or opens [up] an opening for the passages of a fluid and, by these means, controls the pressure in a control pressure space, which is connected with the passage opening.

[An] A conventional injection valve [with the aforementioned distinguishing features is known from] is shown in Figure 2 of the European patent EP 0531 533 B1. The valve actuator of [the known] this injection valve is permanently connected with the armature of the electromagnet and is pressed by the force of a spring against the sealing surface[, so that] to close the passage opening to the control pressure space [is closed]. Such injection valves are usually used for storage injection systems, [where] which utilizes very high control pressures [of] in the order of several hundred [100] bar [occur]. By supplying current to the electromagnet, the valve actuator, which is connected with the armature of the magnet, is raised against the force of a spring, to open [so that] the passage opening [is opened up] and[, by these means,] to decrease the high pressure in the control pressure space [can be decreased]. The injection in the injection valve is then initiated by the decrease in pressure in the control pressure space. By switching off the current to the magnetic coil, the magnet

armature and[, with that,] the valve actuator, which usually is constructed as a cylindrical bolt, strike[s] under the force of the spring with its front surface against the sealing surface and[, with that,] close[s] the passage opening. A good sealing effect of the valve actuator against the very high pressure in the control pressure space is achieved by a valve actuator, which has the smallest possible cross sectional surface and[, with that,] a smallest possible diameter. The smallest possible diameter for the valve actuator is advantageous because [aimed for also for the reason that] errors in angle[, that is, deviations in the alignment of the face surface the valve actuator with the associated sealing seat surface,] resulting from manufacturing inaccuracies, do not lead to leakage gaps. Errors in angle are deviations in the alignment of the face surface of the valve actuator with the associated sealing seat surface. Finally, a high sealing seat pressure and, with that, a more accurate control, are a third reason for having a valve actuator with the smallest possible diameter [and therefore a more accurate control].

It is, however, a disadvantage of [the small diameter of the] a valve actuator having a small diameter and[, with that, of] a the small face surface that the seating impact at the valve opening may be [possibly is] impermissibly high. A further disadvantage [of the small diameter of the valve actuator] is [seen therein] that the closing motion of the magnet armature and of the valve actuator, which together form an appreciable inertial mass, are retarded with little damping to zero, so that recoil effects occur. The largest possible diameter

and[, with that,] a correspondingly large face surface would be desirable for a dampened braking.

It is an object of the present invention to develop an injection valve of the aforementioned construction in such a manner[,] that the above-indicated [target] conflict is resolved, and[, by these means,] a high accuracy of the control valve is achieved even at extremely high pressures. At [and, at] the same time, impermissibly high valve wear due to the impact movement of the valve actuator element is avoided.

Pursuant to the invention, this objective is accomplished [owing to the fact that the] by a valve actuator[, which is actuated by electromagnets, in addition to an actuator-sealing surface, which interacts with the sealing surface of the opening for passage of fluid,] that has an actuator stop surface[, which is] disposed at a distance from the actuator-sealing surface which interacts with the sealing surface of the opening for passage of fluid.

Due to the inventive, spatial separation of the actuator-sealing surface from the actuator stop surface, contrary requirements with respect to the sealing function [on the one hand] and the impact damping function [on the other] can be met at the same time [realized simultaneously]. Accordingly, in an advantageous development of the invention, [it is proposed that] the actuator stop surface is [be] significantly larger than the actuator-sealing surface. The locally separate construction of actuator stop surface and actuator sealing surface furthermore has the advantage that high fluid pressures, such as [those,

which occur] those in the regions of the opening for the passage of fluid [and, with that, in the region of] and the sealing surface of the actuator, can be shifted locally from the electromagnet [and, in this respect,] to protect the electromagnet [is protected] against high hydraulic pressure. Finally, a further advantage [lies therein] is that the electromagnet can be protected better against the effect of the physical and chemical properties of the control fluid.

In [For] a preferred embodiment of [an] the inventive injection valve, the sealing surface of the actuator is the face side of a valve rod, formed by the valve actuator. In a different[,] preferred[,] embodiment, the valve actuator comprises a spherical valve body, which lies against the face side of the valve rod and acts together with the conical sealing surfaces of the passage opening. Moreover, the length of the valve rod is determined essentially by the distance between the sealing surface of the actuator, or of the valve body stop of the valve rod, and the stop surface of the actuator. It is advantageous if the valve actuator is essentially mushroom-shaped, and the stalk of the mushroom [forming] forms the valve rod and the stop surface of the actuator[, in the region of the]. The mushroom cap[,] of the valve actuator is an annular collar, which surrounds the valve rod concentrically.

The length of the valve rod is [larger] longer by a minimum amount than the distance between the sealing surface of the opening for the passage of fluid or the valve body stop of the valve rod and the reference stop for the stop surface of the actuator.

A preferred embodiment of the invention [therefore is one wherein the] includes a valve actuator [is] divided at a separating joint into an actuator stop having an actuator stop surface and a valve rod, which is in operative connection with the sealing surface and the stop of the actuator.

It is a significant advantage of this [inventive, divided configuration of the valve actuator] invention that the valve rod with a smaller diameter[, the diameter of which is distinctly smaller,] can be more easily produced [more easily] independently of the actuator stop. A further advantage [lies therein] is that different materials can be used for the valve rod and the actuator stop. For the divided construction of the valve actuator, it is only necessary to ensure that the opening motion of the valve rod, that is, the lifting from the sealing surface, is ensured by excess pressure from the opening for the passage of fluid or by a supporting, auxiliary spring. The slight excess length of the valve rod, in relation to the distance between the sealing surface of the actuator or the stop of the valve body and the stop surface of the actuator (valve rod protrusion), can be accommodated during the closing motion by the elastic deformation (shortening) of the valve rod.

It is advantageous if the actuator stop is essentially mushroom-shaped, the actuator stop surface being a face surface coming into contact with the valve rod in the region of the foot of the mushroom. Usually, the face surface will be a circular surface, the diameter of which is clearly greater than the diameter of the impacting valve rod.

In a further development of the invention, [it is proposed that] the valve rod [be] is guided axially movably in guide bushings. Moreover, in an effort to keep the sealing surface of the actuator small, a guide bushing is disposed at a small distance from the actuator-sealing surface of the valve rod. In this way, bending vibrations of the free end of the valve rod with the actuator sealing surface are prevented, so that the diameter of the actuator sealing surface need only be slightly larger than that of the passage borehole.

The length of the valve rod preferably is a multiple of its diameter.

In an advantageous development, the sealing surface of the actuator is assigned to a one-part or two-part disk-shaped insert, the control-pressure space adjoining on the side averted from the sealing surface. From a material point of view, the appropriate insert can be adapted with little effort to different stress cases and, by these means, the seal can be improved. With that, of course, by means of parts with different throttling boreholes, which can be combined in modular fashion, supplying and discharging throttles being assigned to different parts, it also being possible to comply with the different requirements of injection characteristics in a simple manner.

BRIEF DESCRIPTON OF THE DRAWINGS

An example of the invention is explained by means of the attached drawings, in which

Figure 1 shows an inventive injection valve in longitudinal section,

Figure 2 shows an enlargement of the region of the electromagnetic control valve of the injection valve of Figure 1,

Figure 3 shows a section of an electromagnetic control valve of the state of the art on a scale, greatly enlarged even more in comparison to that of Figure 2,

Figure 4 shows a variation of the injection valve with an insert in the region of the sealing surface of the actuator,

Figure 5 shows an enlarged view of the immediate region of the actuator surface with a spherical valve body disposed at the end of the valve rod and

Figure 6 shows a variation of an inventive injection valve in longitudinal section, the valve needle lying with its end, which is averted from the injection openings, directly in the control pressure space.

DETAILED DESCRIPTON OF THE DRAWINGS

The injection valve of a high-pressure, storage injection system for an internal combustion engine, shown in Figure 1, has a housing 1. In the lower region of the injection valve, a valve needle 20 is mounted[, by the]. The axial movement of the valve needle 20 opens [which] an injection hole 24 connected to [opposite] a high pressure space 21 [can be opened up,] so that an injection takes place. The high-pressure space 21 is connected [over ducts in the housing 1] with a high-pressure connection 22 through ducts in the housing 1. The movement of the nozzle needle 20 is controlled by an electromagnet 10, the magnet armature

11 of which is permanently connected with a valve actuator 12. The valve actuator 12 is part of a control valve, which is actuated by the [electromagnetic] electromagnet 10. The function of this electromagnetically actuated control valve is explained [by means of the enlargement of] with reference to Figure 2.

Identical components in Figure 2 have been given the same reference numbers as used in Figure 1. The actuator 12 is essentially mushroom-shaped[, the]. The stem of the mushroom [being] is constructed as a valve rod 16, which extends from the region of the mushroom cap up to the sealing surface 17[, into which] having an opening 14a for the passage of fluid from the pressure control space 14 [discharges]. The diameter of the valve rod 16 is selected so that the face surface just covers the opening 14a for the passage of fluid and thus forms a sealing seat on the sealing surface 17. It can be seen easily that the length of the valve rod 16 is a multiple of its diameter. The pressure control space 14 is connected over a throttle borehole with the high-pressure duct system of the injection valve. At the housing, the actuator 12 is mounted axially displaceably by the valve rod 16 in an upper guide bushing 15o and a lower guide bushing 15u. Moreover, the lower guide bushing 15u is disposed so that there is only a small distance between the lower end of the valve rod 16, which is constructed as an actuator surface 16a, and the bottom edge of the lower guide bushing 15u. The annular space 18, which is formed there, is connected with a low-pressure fluid connection 19 of the injection valve. In the closed position of the electromagnetic control valve, shown in Figure 2, the actuator sealing surface

16a of the valve rod 16 closes off the borehole 14a [for the passage of fluid]. An annular collar, surrounding the valve rod 16 concentrically in the region of the mushroom cap of the actuator 12, is constructed as an actuator stop surface 12a and rests on the upper plane surface of the bushing 15o. In the closed position of the electromagnetic control valve that is shown, the valve actuator 12, together with the magnet armature 11, is acted upon by a compression spring, the details of which are not shown and which presses the actuator 12 against the sealing surface 17 and[, at the same time,] onto the upper side of the upper guide bushing 15o, which acts as reference stop for the stop surface 12a of the actuator 12. If electric power is supplied to the electric magnet 10, the magnetic armature 11 pulls the actuator 12 up against the force of the compression spring[, so that]. As a result, the borehole 14a for the passage of fluid is opened, and[, with that,] a pressure decrease results in the control pressure space 14, which brings about a lifting of the valve needle [12] 20 and, with that, an injection. When the power is switched off, the force of the compression spring knocks the valve actuator 12, together with the armature of the magnet 11, downward. Moreover, the stop surface 12a of the actuator 12, which is much larger than sealing surface 16a of the actuator of the valve rod 16, acts strictly as a damping and stop surface for decaying the mass forces of the magnet armature and of the valve actuator. At the lower end of the valve rod 16, the very much smaller sealing surface 16a of the actuator 12 takes over the function of a sealing seat and, because of the small surface itself, does so with great accuracy and without the risk of leakages even at extremely high control pressures.

[This] The risk of leakage in a conventional injection valve is indicated by means of a greatly enlarged representation of Figure 3 [of a conventional injection valve]. The structure of this [such a] valve is similar to that shown in Figures 1 and 2, [however] with the difference that the opening 14a for the passage of fluid, which is connected [with] to the control pressure space 14, is at [taken up to a] housing surface 13, which has the function of both a stop and a sealing surface. The valve actuator 12 once again has a [is constructed in] mushroom shape [fashion], but does not have the inventive valve rod 16. In order for [So that] the damping and impact effect of the valve actuator 12 [does] not to become too small, the diameter of the sealing seat and impact surface is selected to be clearly larger than the diameter of the opening 14a for the passage of fluid. [In this connection,] Therefore, there is the risk [must be accepted that, as a result of] that an angular error, that is, a deviation of the sealing and stop surface from precisely a right angle with respect to the longitudinal axis of the valve actuator 12 may produce, a small gap 5, even when the valve actuator 12 is in contact with the housing surface 13. [which results in a permanent drop in pressure in the high pressure region 14, results even in the contacting state of the valve actuator 12.] Such a small gap can result in a permanent drop in pressure in the high pressure region 14.

A region of an injection valve, which corresponds to that of Figure 2 and is modified in the region of the actuator-sealing surface, is shown in Figure 4. As shown on an enlarged scale in Figure [4] 6, the valve rod 16 acts on a valve body

30, which is constructed as a sphere. The valve body 30 lies in contact with a conically shaped sealing surface 17 of the opening 14a for the passage of fluid. The opening 14a for the passage of fluid contains a discharge choke 33. The use of a separate valve body 30, which may also have a shape different from that of a sphere, has the advantage that the sealing is improved. In particular, it is also possible to use different materials for the valve rod 16 and the valve body 30. A further improvement of the sealing arises from the use of an insert part in the form of a disk-shaped part 37, which contains the drainage choke 33. With respect to the material and the borehole of the choke, this part 37 can easily be matched optimally to different stress cases. By making available insert parts with choke boreholes of different size, it is furthermore possible to vary the injection characteristics by a simple exchange. Likewise, it is possible to make available second parts 34 with different inlet chokes 36, in order to match the injection characteristics by a simple exchange. This procedure of changing the amount injected and the course of the injection by replacing first and second insert parts with different chokes is known, as such, from the EP 0 844 385 A1. By means of a centering and holding clamp 39, the part 37 is connected with a sleeve 38, in which the valve rod 16 with its guide bushings 15o and 15u is [taken up] <u>disposed</u>. These parts form a structural unit, which can be adjusted by themselves in relation to the projecting length of the valve rod.

Figure 5 shows an inventive injection valve, which also contains a disk-shaped insert part 32. The control pressure space 14 adjoins immediately the

side of the insert part 32, which is averted from the sealing surface 17. With its rear end, the nozzle needle 20 lies directly in the pressure control space 14. The insert part 32 is incorporated between the nozzle holder and the injection nozzle 40. The injection nozzle 40 and the insert part 32 are pressed against the nozzle holder by a nozzle nut, so that the high pressure regions[, which are under high pressure,] are connected with one another. The insert part 32 has a central borehole as an opening 14a for the passage of fluid to the control pressure space 14 and a calibrated discharge choke 33 in the region opposite the valve rod 16. In addition, the insert part 32 contains a high-pressure duct 41, which passes the fuel[, which is] under injection pressure[,] from a high-pressure connection 22 to a high-pressure duct in the injection nozzle. The high-pressure duct 41 in the insert part 32 has a pipeline connection to the central borehole in the insert part 32 and there is a calibrated inlet choke 36 in this pipeline connection. Preferably, as shown in Figure [4] 6, the insert part has a conical sealing surface 17, in which a spherical valve body 30 provides the seal. A corresponding construction is known from US patent 5,832,899.

In its function, the injector corresponds to that described in Figures 1 and 2. Because of the construction with the control spaces assigned directly to the two sides of the insert part, the sealing is reduced essentially to this region, which can easily be controlled. In particular, by making available a suitable insert part, it is easily possible to react to different stress cases and to different

requirements with regard to the amount injected and to the course of the injection.

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INJECTION VALVE FOR AN INTERNAL COMBUSTION ENGINE

The invention relates to an injection valve for an internal combustion engine with a control valve, which is activated electromagnetically and, by means of a valve actuator, alternatively closes off or opens up an opening for the passages of a fluid and, by these means, controls the pressure in a control pressure space, which is connected with the passage opening.

An injection valve with the aforementioned distinguishing features is known from Figure 2 of the European patent EP 0531 533 B1. The valve actuator of the known injection valve is permanently connected with the armature of the electromagnet and is pressed by the force of a spring against the sealing surface, so that the passage opening to the control pressure space is closed. Such injection valves are usually used for storage injection systems, where very high control pressures of the order of several 100 bar occur. By supplying current to the electromagnet, the valve actuator, which is connected with the armature of the magnet, is raised against the force of a spring, so that the passage opening is opened up and, by these means, the high pressure in the control pressure space can be decreased. The injection in the injection valve is then initiated by the decrease in pressure in the control pressure space. By switching off the current to the magnetic coil, the magnet armature and, with that, the valve actuator, which usually is constructed as a cylindrical bolt, strikes under the force of the spring with its front surface against the sealing surface and, with that, closes the passage opening. A good sealing effect of the valve actuator against the very high pressure in the control pressure space is achieved by a valve actuator, which has the smallest possible cross sectional surface and, with that, a small diameter. The smallest possible diameter for the valve actuator is aimed for also for the reason that errors in angle, that is, deviations in the alignment of the face surface the valve actuator with the associated sealing seat surface, resulting from manufacturing inaccuracies, do not lead to leakage gaps. Finally, a high sealing seat pressure and, with that, a more accurate control, are a third reason for having a valve actuator with the smallest possible diameter and therefore a more accurate control.

It is, however, a disadvantage of the small diameter of the valve actuator and, with that, of the small face surface that the seating impact at the valve opening possibly is impermissibly high. A further disadvantage of the small diameter of the valve actuator is seen therein that the closing motion of the magnet armature and of the valve actuator, which together form an appreciable inertial mass, are retarded with little damping to zero, so that recoil effects occur. The largest possible diameter and, with that, a correspondingly large face surface would be desirable for a dampened braking.

It is an object of the present invention to develop an injection valve of the aforementioned construction in such a manner, that the above-indicated target conflict is resolved and, by these means, a high accuracy of the control valve is achieved even at extremely high pressures and, at the same time, impermissibly high valve wear due to the impact movement of the valve actuator element is avoided.

Pursuant to the invention, this objective is accomplished owing to the fact that the valve actuator, which is actuated by electromagnets, in addition to an actuator-sealing surface, which interacts with the sealing surface of the opening for passage of fluid, has an actuator stop surface, which is disposed at a distance form the actuator-sealing surface.

Due to the inventive, spatial separation of the actuator-sealing surface from the actuator stop surface, contrary requirements with respect to the sealing function on the one hand and the impact damping function on the other can be realized simultaneously. Accordingly, in an advantageous development of the invention, it is proposed that the actuator stop surface be significantly larger than the actuator-sealing surface. The locally separate construction of actuator stop surface and actuator sealing surface furthermore has the advantage that high fluid pressures, such as those, which occur in the region of the opening for the passage of fluid and, with that, in the region of the sealing surface of the actuator, can be shifted locally from the electromagnet and, in this respect, the electromagnet is protected against high hydraulic pressure.

Finally, a further advantage lies therein that the electromagnet can be protected better against the effect of the physical and chemical properties of the control fluid.

For a preferred embodiment of an inventive injection valve, the sealing surface of the actuator is the face side of a valve rod, formed by the valve actuator. In a different, preferred, embodiment, the valve actuator comprises a spherical valve body, which lies against the face side of the valve rod and acts together with the conical sealing surfaces of the passage opening. Moreover, the length of the valve rod is determined essentially by the distance between the sealing surface of the actuator or of the valve body stop of the valve rod and the stop surface of the actuator. It is advantageous if the valve actuator is essentially mushroom-shaped, the stalk of the mushroom forming the valve rod and the stop surface of the actuator, in the region of the mushroom cap, is an annular collar, which surrounds the valve rod concentrically.

The length of the valve rod is larger by a minimum amount than the distance between the sealing surface of the opening for the passage of fluid or the valve body stop of the valve rod and the reference stop for the stop surface of the actuator.

A preferred embodiment of the invention therefore is one wherein the valve actuator is divided at a separating joint into an actuator stop having an actuator stop surface and a valve rod, which is in operative connection with the sealing surface and the stop of the actuator.

It is a significant advantage of this inventive, divided configuration of the valve actuator that the valve rod, the diameter of which is distinctly smaller, can be produced more easily independently of the actuator stop. A further advantage lies therein that different materials can be used for the valve rod and the actuator stop. For the divided construction of the valve actuator, it is only necessary to ensure that the opening motion of the valve rod, that is, the lifting from the sealing surface, is ensured by excess pressure from the opening for the passage of fluid or by a supporting, auxiliary spring. The slight excess length of the valve rod in relation to the distance between the sealing surface of the actuator or the stop of the valve body and the stop

surface of the actuator (valve rod protrusion) can be accommodated during the closing motion by the elastic deformation (shortening) of the valve rod.

It is advantageous if the actuator stop is essentially mushroom-shaped, the actuator stop surface being a face surface coming into contact with the valve rod in the region of the foot of the mushroom. Usually, the face surface will be a circular surface, the diameter of which is clearly greater than the diameter of the impacting valve rod.

In a further development of the invention, it is proposed that the valve rod be guided axially movably in guide bushings. Moreover, in an effort to keep the sealing surface of the actuator small, a guide bushing is disposed at a small distance from the actuator-sealing surface of the valve rod. In this way, bending vibrations of the free end of the valve rod with the actuator sealing surface are prevented, so that the diameter of the actuator sealing surface need only be slightly larger than that of the passage borehole.

The length of the valve rod preferably is a multiple of its diameter.

In an advantageous development, the sealing surface of the actuator is assigned to a one-part or two-part disk-shaped insert, the control-pressure space adjoining on the side averted from the sealing surface. From a material point of view, the appropriate insert can be adapted with little effort to different stress cases and, by these means, the seal can be improved. With that, of course, by means of parts with different throttling boreholes, which can be combined in modular fashion, supplying and discharging throttles being assigned to different parts, it also being possible to comply with the different requirements of injection characteristics in a simple manner.

An example of the invention is explained by means of the attached drawings, in which

Figure 1 shows an inventive injection valve in longitudinal section,

Figure 2 shows an enlargement of the region of the electromagnetic control valve of the injection valve of Figure 1,

Figure 3 shows a section of an electromagnetic control valve of the state of the art on a scale, greatly enlarged even more in comparison to that of Figure 2,

Figure 4 shows a variation of the injection valve with an insert in the region of the sealing surface of the actuator,

Figure 5 shows an enlarged view of the immediate region of the actuator surface with a spherical valve body disposed at the end of the valve rod and

Figure 6 shows a variation of an inventive injection valve in longitudinal section, the valve needle lying with its end, which is averted from the injection openings, directly in the control pressure space.

The injection valve of a high-pressure, storage injection system for an internal combustion engine, shown in Figure 1, has a housing 1. In the lower region of the injection valve, a valve needle 20 is mounted, by the axial movement of which an injection hole 24 opposite a high pressure space 21 can be opened up, so that an injection takes place. The high-pressure space 21 is connected over ducts in the housing 1 with a high-pressure connection 22. The movement of the nozzle needle 20 is controlled by an electromagnet 10, the magnet armature 11 of which is permanently connected with a valve actuator 12. The valve actuator 12 is part of a control valve, which is actuated by the electromagnetic 10. The function of this electromagnetically actuated control valve is explained by means of the enlargement of Figure 2.

Identical components in Figure 2 have been given the same reference numbers used in Figure 1. The actuator 12 is essentially mushroom-shaped, the stem of the mushroom being constructed as a valve rod 16, which extends from the region of the mushroom cap up to

the sealing surface 17, into which an opening 14a for the passage of fluid from the pressure control space 14 discharges. The diameter of the valve rod 16 is selected so that the face surface just covers the opening 14a for the passage of fluid and thus forms a sealing seat on the sealing surface 17. It can be seen easily that the length of the valve rod 16 is a multiple of its diameter. The pressure control space 14 is connected over a throttle borehole with the high-pressure duct system of the injection valve. At the housing, the actuator 12 is mounted axially displaceably by the valve rod 16 in an upper guide bushing 15o and a lower guide bushing 15u. Moreover, the lower guide bushing 15u is disposed so that there is only a small distance between the lower end of the valve rod 16, which is constructed as an actuator surface 16a, and the bottom edge of the lower guide bushing 15u. The annular space 18, which is formed there, is connected with a low-pressure fluid connection 19 of the injection valve. In the closed position of the electromagnetic control valve, shown in Figure 2, the actuator sealing surface 16a of the valve rod 16 closes off the borehole 14a for the passage of fluid. An annular collar, surrounding the valve rod 16 concentrically in the region of the mushroom cap of the actuator 12, is constructed as an actuator stop surface 12a and rests on the upper plane surface of the bushing 15o. In the closed position of the electromagnetic control valve that is shown, the valve actuator 12, together with the magnet armature 11, is acted upon by a compression spring, the details of which are not shown and which presses the actuator 12 against the sealing surface 17 and, at the same time, onto the upper side of the upper guide bushing 15o, which acts as reference stop for the stop surface 12a of the actuator 12. If electric power is supplied to the electric magnet 10, the magnetic armature 11 pulls the actuator 12 up against the force of the compression spring, so that the borehole 14a for the passage of fluid is opened and, with that, a pressure decrease results in the control pressure space 14, which brings about a lifting of the valve needle 12 and, with that, an injection. When the power is switched off, the force of the compression spring knocks the valve actuator 12, together with the armature of the magnet 11, downward. Moreover, the stop surface 12a of the actuator 12, which is much larger than sealing surface 16a of the actuator of the valve rod 16, acts strictly as a damping and stop surface for decaying the mass forces of the magnet armature and of the valve actuator. At the lower end of the valve rod 16, the very much smaller sealing surface 16a of the actuator 12 takes over the function of a sealing seat and, because of the small

surface itself, does so with great accuracy and without the risk of leakages even at extremely high control pressures.

This risk is indicated by means of a greatly enlarged representation of Figure 3 of a conventional injection valve. The structure of such a valve is similar to that shown in Figures 1 and 2, however with the difference that the opening 14a for the passage of fluid, which is connected with the control pressure space 14, is taken up to a housing surface 13, which has the function of a stop and sealing surface. The valve actuator 12 once again is constructed in mushroom fashion, but does not have the inventive valve rod 16. So that the damping and impact effect of the valve actuator 12 does not become too small, the diameter of the sealing seat and impact surface is selected to be clearly larger than the diameter of the opening 14a for the passage of fluid. In this connection, the risk must be accepted that, as a result of an angular error, that is, a deviation of the sealing and stop surface from precisely a right angle with respect to the longitudinal axis of the valve actuator 12, a small gap 5, which results in a permanent drop in pressure in the high pressure region 14, results even in the contacting state of the valve actuator 12.

A region of an injection valve, which corresponds to that of Figure 2 and is modified in the region of the actuator-sealing surface, is shown in Figure 4. As shown on an enlarged scale in Figure 4, the valve rod 16 acts on a valve body 30, which is constructed as a sphere. The valve body 30 lies in contact with a conically shaped sealing surface 17 of the opening 14a for the passage of fluid. The opening 14a for the passage of fluid contains a discharge choke 33. The use of a separate valve body 30, which may also have a shape different from that of a sphere, has the advantage that the sealing is improved. In particular, it is also possible to use different materials for the valve rod 16 and the valve body 30. A further improvement of the sealing arises from the use of an insert part in the form of a disk-shaped part 37, which contains the drainage choke 33. With respect to the material and the borehole of the choke, this part 37 can easily be matched optimally to different stress cases. By making available insert parts with choke boreholes of different size, it is furthermore possible to vary the injection characteristics by a simple exchange. Likewise, it is possible to make available second parts 34

with different inlet chokes 36, in order to match the injection characteristics by a simple exchange. This procedure of changing the amount injected and the course of the injection by replacing first and second insert parts with different chokes is known, as such, from the EP 0 844 385 A1. By means of a centering and holding clamp 39, the part 37 is connected with a sleeve 38, in which the valve rod 16 with its guide bushings 15o and 15u is taken up. These parts form a structural unit, which can be adjusted by themselves in relation to the projecting length of the valve rod.

Figure 5 shows an inventive injection valve, which also contains a disk-shaped insert part 32. The control pressure space 14 adjoins immediately the side of the insert part 32, which is averted from the sealing surface 17. With its rear end, the nozzle needle 20 lies directly in the pressure control space 14. The insert part 32 is incorporated between the nozzle holder and the injection nozzle 40. The injection nozzle 40 and the insert part 32 are pressed against the nozzle holder by a nozzle nut, so that the regions, which are under high pressure, are connected with one another. The insert part 32 has a central borehole as an opening 14a for the passage of fluid to the control pressure space 14 and a calibrated discharge choke 33 in the region opposite the valve rod 16. In addition, the insert part contains a high-pressure duct 41, which passes the fuel, which is under injection pressure, from a high-pressure connection 22 to a high-pressure duct in the injection nozzle. The high-pressure duct 41 in the insert part 32 has a pipeline connection to the central borehole in the insert part 32 and there is a calibrated inlet choke 36 in this pipeline connection. Preferably, as shown in Figure 4, the insert part has a conical sealing surface 17, in which a spherical valve body 30 provides the seal. A corresponding construction is known from US patent 5,832,899.

In its function, the injector corresponds to that described in Figures 1 and 2. Because of the construction with the control spaces assigned directly to the two sides of the insert part, the sealing is reduced essentially to this region, which can easily be controlled. In particular, by making available a suitable insert part, it is easily possible to react to different stress cases and to different requirements with regard to the amount injected and to the course of the injection.

ART 34 AMDT

Claims

1. An injection valve for an internal combustion engine with a control valve, which is activated especially electromagnetically and, by means of a valve actuator (12), alternatively closes off or opens up an opening (14a) for the passages of a fluid, which is assigned to a sealing surface (13, 17) and, by these means, controls the pressure in a control pressure space (14), which is connected with the passage opening, the valve actuator (12), in addition to an actuator sealing surface (16a), which acts together with the sealing surface (17) of the opening (14a) for the passage of fluid, having an actuator stop surface (12a), which is disposed at a distance from the actuator sealing surface (16a), the valve actuator (12) having a valve rod (16) which, in relation to the distance between the sealing surface (16a) and the stop surface (12a) of the actuator has an overlength, wherein, during the closing movement. the overlength is taken up by the elastic deformation of the valve rod (16).

2. The injection valve of claim 1, wherein the stop surface (12a) of the actuator is significantly larger than the sealing surface (16a).

3. The injection valve of claims 1 or 2, wherein the valve actuator (12) is formed with a one-part or a two-part valve rod (16).

4. The injection valve of claim 3, wherein the valve actuator (12) contains a valve body (30), which touches the front face of the valve rod (16) and contains the sealing surface (16a) of the actuator.

5. The injection valve of claim 4, wherein the valve body (30) is constructed as a sphere, which interacts with the opening (14a) for the passage of fluid, forming a seal.

6. The injection valve of claim 3, wherein the sealing surface (16a) of the actuator is the front face of the valve rod (16) formed by the valve actuator (12).

Claims

1. An injection valve for an internal combustion engine with a control valve, which is activated especially electromagnetically and which, by means of a valve actuator (12), alternatively closes off or opens up an opening (14a) for the passages of a fluid, which is assigned to a sealing surface (13, 17) and, by these means, controls the pressure in a control pressure space (14), which is connected with the passage opening, wherein the valve actuator (12), in addition to an actuator sealing surface (16a), which acts together with the sealing surface (17) of the opening (14a) for the passage of fluid, has an actuator stop surface (12a), which is disposed at a distance from the actuator sealing surface (16a).

2. The injection valve of claim 1, wherein the stop surface (12a) of the actuator is significantly larger than the sealing surface (16a) of the actuator.

3. The injection valve of claims 1 or 2, wherein the valve actuator (12) is formed with a one-part or a multi-part valve rod (16).

4. The injection valve of claim 3, wherein the valve actuator (12) contains a valve body (30), which touches the front face of the valve rod (16) and contains the sealing surface (16a) of the actuator.

5. The injection valve of claim 4, wherein the valve body (30) is constructed as a sphere, which interacts with the opening (14a) for the passage of fluid, forming a seal.

6. The injection valve of claim 3, wherein the sealing surface (16a) of the actuator is the front face of the valve rod (16) formed by the valve actuator (12).

7. The injection valve of one of the claims 3 to 6, wherein the valve actuator (12) is essentially mushroom-shaped, the stem of the mushroom forming the valve rod (16) and the

stop surface (12a) of the actuator being an annular collar, concentrically surrounding the valve rod (16) in the region of the mushroom cap.

8. The injection valve of one of the claims 3 to 7, wherein the valve actuator (12) is divided in a dividing joint 120 into an actuator stop, having the stop surface (12a) of the actuator, and a valve rod (16), which is in operative connection with the sealing surface (16a) and the stop of the actuator.

9. The injection valve of one of the claims 3 to 8, wherein the actuator stop is essentially mushroom-shaped, the stop surface (12a) of the actuator being an end face, contacting the valve rod (16) in the region of the foot of the mushroom.

10. The injection valve of one of the claims 3 to 9, wherein the valve rod (16) is guided axially movably in at least one guide bushing (15o, 15u).

11. The injection valve of claim 10, wherein a guide bushing (15u) is disposed at a small distance from the sealing surface (16a) of the actuator.

12. The injection valve of one of the claims 3 to 11, wherein the length of the valve rod (16) is a multiple of its diameter.

13. The injection valve of claims 1 to 12, wherein the sealing surface (17) is formed in the end face of a disk-shaped insert part (32) and adjoins the control pressure space (14) on the side averted from the sealing surface (17).

14. The injection valve of claim 13, wherein the insert part (32) is formed in two parts with a first part (37), which contains an opening (14a) for the passage of fluid and a discharge choke (33) and a second part (34) at the control pressure space side, with a borehole (35), which connects the control pressure space (14) with an opening (14a) for the passage of fluid.

15. The injection valve of claim 14, wherein the second part (34) contains an inlet choke (36), which is connected with the borehole (35).

16. The injection valve of claim 13, wherein the insert part (32) contains an inlet choke (36) in addition to the outlet choke (33).

17. The injection valve of claims 13 or 14, wherein the control pressure space (14) is connected with an inlet choke (36).

18. The injection valve of one of the claims 13 to 17, wherein the rear end of the valve needle (20), averted from the nozzle needle seat surface, lies in the control pressure space (14).

19. The injection valve of claim 18, wherein the insert part (32) forms a stop for the valve needle (20).

20. The injection valve of one of the claims 13 to 19, wherein the insert part (32), a centering and holding clamp (39) and a sleeve (38), in which at least one valve rod (16) and at least one guide bushing (15o, 15u) with the actuator stop surface (12a) is taken up, form a structural unit, which can be pre-adjusted by itself in relation to the protrusion of the valve rod.

Fig. 1

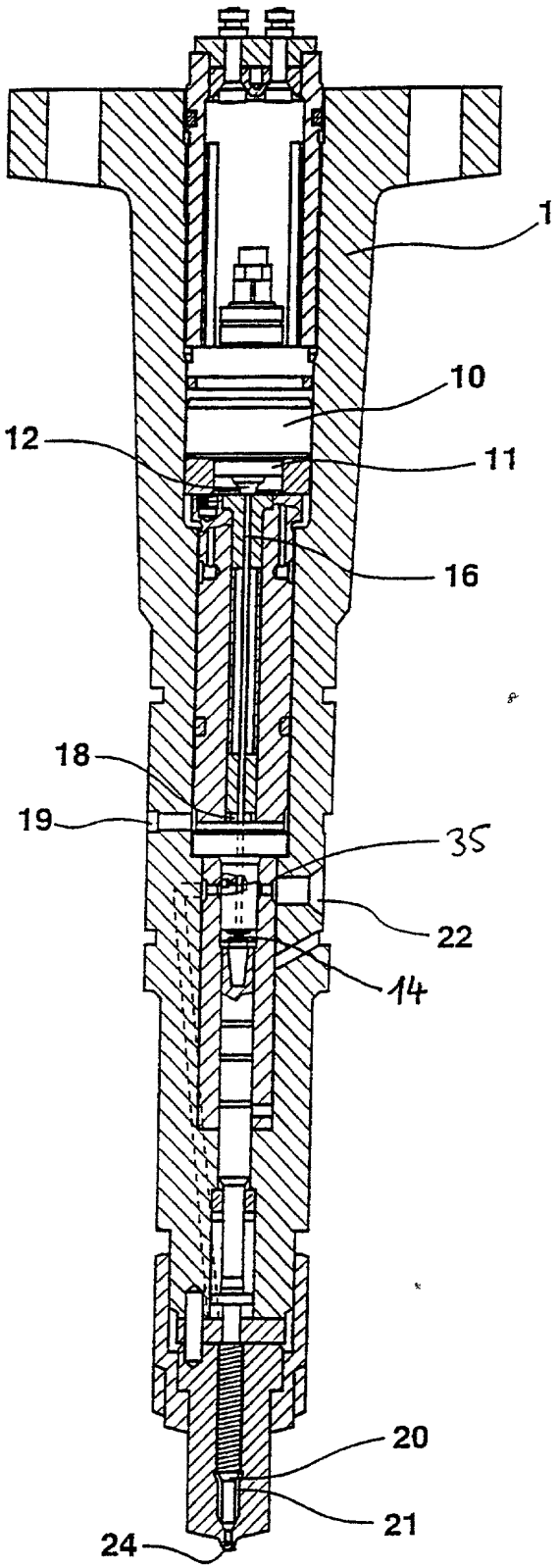


Fig. 2

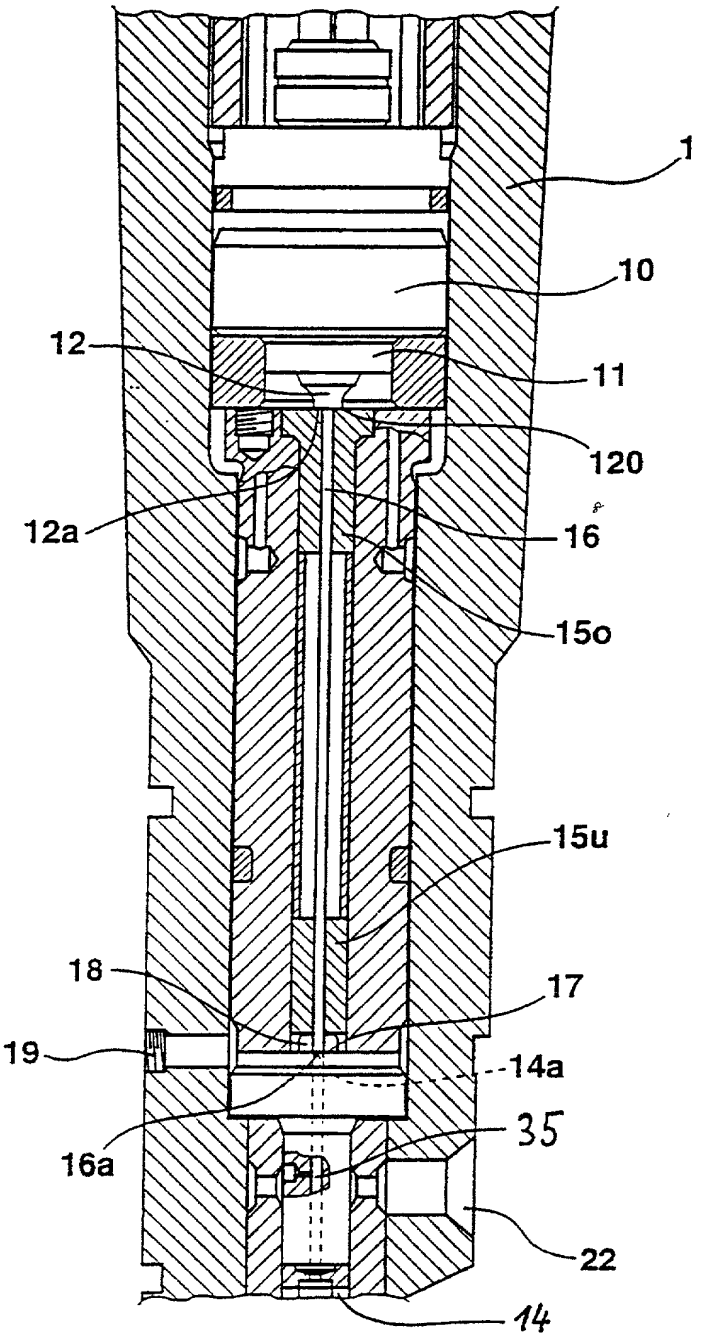
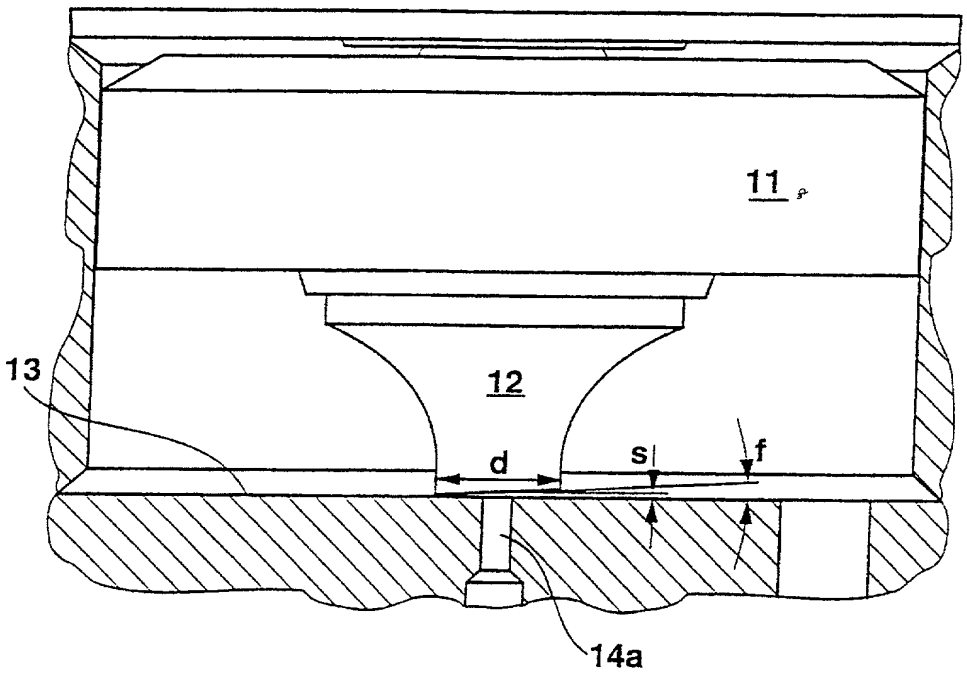


Fig. 3



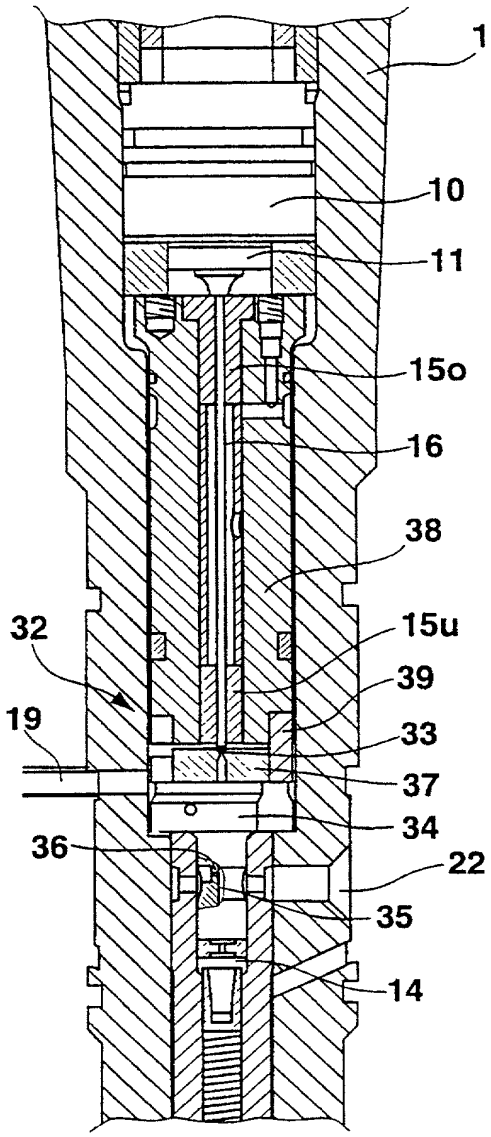


Fig. 4

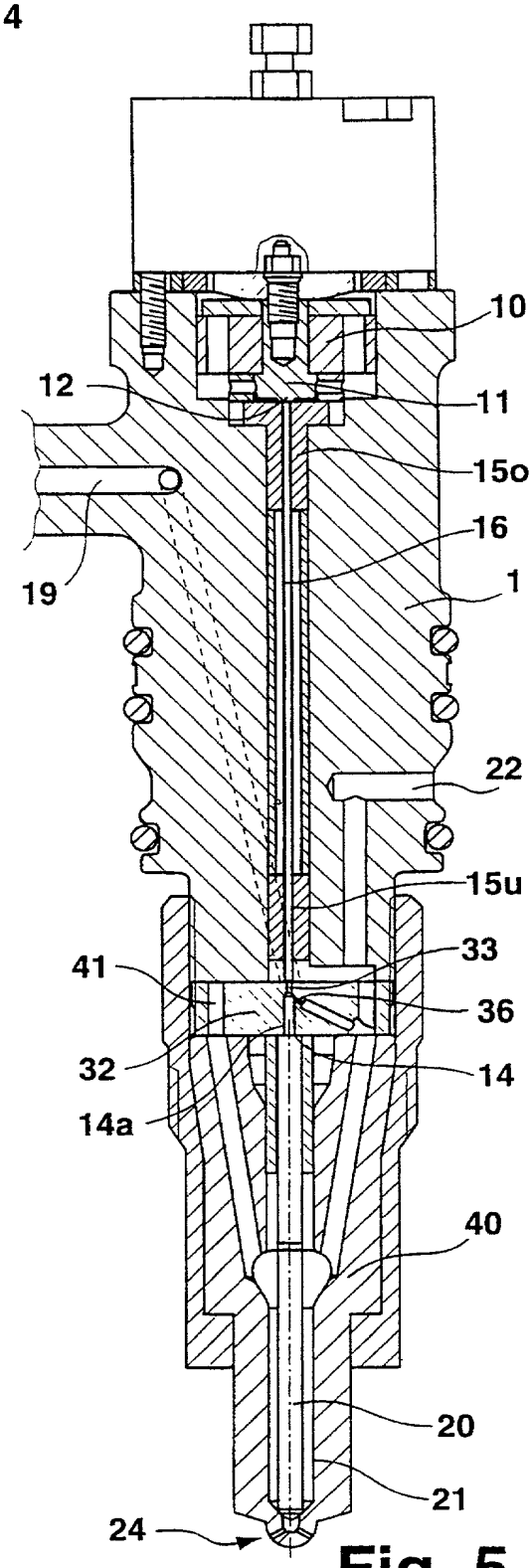


Fig. 5

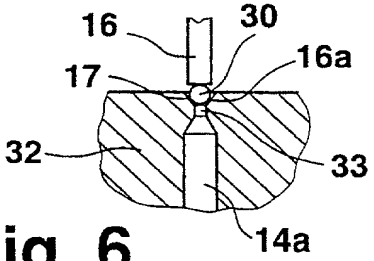


Fig. 6

Attorney Docket No. 842FR/50684

DECLARATION AND POWER OF ATTORNEY

(For Use with Application Data Sheet)

As the below named inventor(s), I/we declare that:

This declaration is directed to:

___ The attached application, or
X International Application No. PCT/EP00/04815, filed on May 26, 2000,
___ as amended on _____ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including material information which became available between the filing date of the prior application and the National or PCT International filing date of the continuation-in-part application, if applicable;

I/we hereby appoint the practitioners at **CROWELL & MORING L.L.P.**, whose Customer Number is:

23911
PATENT TRADEMARK OFFICE

as my/our attorneys to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith; and

All statements made herein of my/our own knowledge are true; all statements made herein on information and belief are believed to be true, and further these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

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